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Specific gravity and dropping speed in eggs of *Oncomelania hupensis*, a snail intermediate host of Schistosomiasis

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Abstract

Oncomelania hupensis (Gredler, 1881) is an intermediate host of *Schistosomiasis japonica* in China. In order to understand the factors controlling sedimentation and drifting of adult snails and snail eggs in rivers, three aspects were investigated by experiment. Firstly, the specific gravity of the snail eggs was found to be 2.29 g/cm^3; secondly, the range of dropping speed of the snail eggs through a water column was found to be 1.19 to 3.77 cm/s; thirdly, a formula for dropping speed of the eggs was established. The formula was statistically validated by comparison with observed values. The results are relevant to both the development and design of irrigation schemes, and also to river management, where dispersal of snails and their eggs needs to be controlled.

Key words: *Oncomelania hupensis*, snail eggs, specific gravity, dropping speed.

Introduction

Schistosomiasis is now endemic in 74 countries and territories of the world and *Schistosoma japonica* is mainly distributed in south-east Asian and the Western Pacific region (WHO 1991). One of the most difficult problems for schistosomiasis control is the dispersal of the snail intermediate host along rivers and irrigation schemes. This dispersal expands the endemic areas of schistosomiasis and increases the prevalence of the disease (Hunter, 1993; Mott, 1990). It is important, therefore, to explore methods for controlling the snail host. The ecology of the water snails in relation to water flow has been well-researched and some effective models have been proposed (Dussart,1987; Yin, *et al.*,1987, Bolton, 1988; Xu & Fang, 1989; Yang, *et al.*, 1992; & Green, *et al.*, 1992).

S. japonica is mainly distributed in eight provinces in the southern part of China, with foci in five provinces along the middle and lower reaches of the Yangtze River (MPH,1991; Mao, 1990). *Oncomelania hupensis*, the intermediate snail host of *S . japonica*, is mainly distributed on banksides of rivers, ditches and irrigation schemes throughout the flood plain; snail habitats are increasing year by year. The disease seriously threatens farming and the daily life of local people, and also affects the socio-economic development of these areas (MPH, 1989; Chen, 1989; Xu & Fang, 1990). Thus, snail control is a one of the most important factors for disease control. To understand the parameters which might control the drifting and dropping of snails and their eggs in rivers, experiments on specific gravity and dropping speed for the adult snails have been carried out (Xu, *et al.* 1996). The aim of present study was, therefore, to make similar measurement on the specific gravity and dropping speed for the eggs of *O. hupensis*, to contribute to the development of a scientific basis for the prevention of snail dispersal.

Materials and Methods

Snail eggs. Snail eggs were obtained from snail habitats in Han Yang county in Hubei province at the end of April 1997. Adult snails were collected and put in a bowl of mud at 25 ºC for 15 days. After two weeks, the snails were removed and snail eggs were washed from the surface of the mud in the bowl. All eggs selected for measurement were in the primitive gut embryonic stage. A 25 ml specific gravity flask was used to determined specific gravity. Dropping speed was measured in a water-filled glass tube of 160 cm length and 4.5 internal diameter, in which a water column length of 130 cm was available to observe the eggs dropping.

Measurement of the specific gravity of the snail eggs was carried out in accordance with the routine measurement method for the determination of specific gravity of river silt in China. (Sha, 1963).

The snail eggs washed from the mud bowl were collected by suction tube in a tissue culture dish of 9 cm diameter. The snail eggs were weighed and separated on Whatman's No.4 filter paper for 8 h to absorb excess surface water from the eggs. The flask containing the eggs was put into a desiccator for 8 h to continue the drying process. The snail eggs were weighed, placed in a graduated flask and made up to 25 ml; the flask was then filled distilled water and shaken gently before being weighed on a balance. Thus the weight included graduated flask, the snail eggs and distilled water. The distilled water and snail eggs were then discarded from the flask. The flask was dried inside and outside, distilled water was added to the level of 25 ml and the flask was weighed again; thus the weight included only graduated flask and distilled water.

The following formula was used to calculate the specific gravity of the snail eggs:

$$SGe = g_e \ / \ g_e + g_1 - g_2 \times SG_{H2O}$$

Where:

SGe : specific gravity of the snail eggs. (g/cm^3)

g_e: weight of the snail eggs (g)

g_1: weight of flask plus distilled water (g)

g_2: weight of the snail eggs plus flask and distilled water (g)

SG_{H2O}: specific gravity of distilled water at 4 ºC (g/cm^3)

Measurement of dropping speed of snail eggs in stable water. The diameter of each snail egg was measured under the microscope. The egg was put into the 160 cm glass tube and dropping speed was measured directly (MWE 1965).

Establishment and deduction of the formula for dropping speed of snail eggs. The formula for snail eggs dropping speed in stable water was based on the established principle for measuring the dropping speed of a round object (Qia & Wan, 1983). The difference between the theoretically predicted and the measured values was statistically investigated.

Results

Specific gravity of snail eggs. The mean specific gravity was 2.29 g/cm^3, minimum of 2.25 g /cm^3, maximum of 2.33 g /cm^3 and standard deviation of 0.0162.

Dropping speed of the snail eggs. The diameter of each of 84 snail eggs was measured; 74 eggs had shapes which resembled a spherical pill. The range of diameter of the snail eggs was 0.43 to 0.83 mm; the dropping speed of the snail eggs was mean 2.48 cm/s, minimum of 1.19 cm/s, maximum of 3.77 cm/s and standard deviation of 0.2614.

The establishment and deduction of formula for dropping speed of the snail eggs. A snail egg drops with uniform acceleration when water resistance and the specific gravity of the egg become balanced. Because the shape of the snail-eggs is similar to spherical pill, the force (G) acting on the eggs in stable water is given by:

$$G = \pi/6 \times d^3(\gamma_1 - \gamma_0) \text{ .... (1) (Qian \& Wan, 1983).}$$

Where:

G:	Gravitational force acting on the snail eggs in water (g)
F:	Water resistance.
W:	Dropping speed of the snail eggs in stable water. (cm/s)
Ca:	Resistance coefficient.
γ_1:	Specific gravity of the snail eggs (g/cm^3)
γ_0:	Specific gravity of water. (g/cm^3)
g:	Gravity plus speed. (cm/s)
d:	Diameter of the snail eggs (mm)

Snail eggs which drop in water meet water resistance. The resistance equation of the snail eggs in stable water is:

$$F = Ca \times \gamma_0 \times \pi/4 \times d^2 \times w^2/2g \text{ ....(2)}$$

When G = F, the resistance of the snail eggs drops with uniform acceleration. The equation is therefore

$$Ca = 4/3\ (\gamma_1 - \gamma_0)/\gamma_0 \times gd/w^2 \text{ ....(3)}$$

Based on a general principle of silt motion, there is a resistance coefficient (Rd) (also called circumflow). The function of the relationship is given by :

$$Ca = f(Rd) \quad ....(4)$$

in which $Rd = wd/v$, where w = dropping speed of the snail eggs; d = diameter of the snail eggs and v = flow rate. When a correlation was made with the experimental data, the result was

$$Ca = 250/Rd \quad ....(5)$$

Therefore, the dropping speed formula of the snail eggs in stable water can be formed from equation (3) and (5), and is:

$$w = 4/750v \times (\gamma_1-\gamma_0/\gamma_0) \times gd^2 \quad ....(6)$$

The unit of each symbol in the formula is:

w = cm/s
d = cm
γ_1 = 2.29 g/cm^3
γ_0 = 1g/cm^3
g = 981 cm/s^2, which can change with the water temperature.

A *t* test was used to investigate the difference between the practical measured value and the predicted value of the dropping speed. The *t* value is 0.677, ($t_{0.05} = 1.994$) $P > 0.05$, there was no significant difference between the predicted and measured value.

Discussion

Oncomelania hupensis is distributed mainly in marshland and lakes in southern China. The peak egg laying period is spring and autumn of every year. The snail eggs are light and small, so they drift easily in the flood season. Once the eggs settle in suitable hatching sites, new snail populations develop. Therefore, it is important to try to control the dispersal of snails and their eggs in irrigation schemes in endemic areas.

The snails lay eggs at the edge of lakes and rivers. When eggs are laid on moist mud, the eggs become covered with soft mud so that they have the appearance of a small mud pill. It has been observed that if the mud layer comes off at the first development stage of the eggs, the eggs do not develop into a juvenile snail (Guo, 1983). Thus, the mud layer seems to plays an important role in the growth phase of the snail eggs. Microscopic observation showed that the drying procedures used here did not damage the internal or external physical and biological characteristics of the eggs. The measured values would therefore appear to be reliable.

The specific gravity of the eggs of *O. hupensis* is an indispensable basic physical parameter in the calculation of dropping speed and drift distance for snail eggs in still- and running-water. This information may contribute to a theoretical basis for the prevention of snail dispersal in the field.

Based on the dropping speed of snail eggs measured in this study, the drifting style of the snail eggs can be compared with the dropping speed of silt in rivers. Usually, 0.5 mm diameter silt particles are suspended in flowing water but drop at a rate of 5.67cm/s in still water. Our results show the dropping speed for snail eggs to be 1.19 to 3.77 cm/s, which is lower than the result for silt that is suspended as drift in rivers. Therefore, it can be inferred that snail egg dispersal will at least conform with the drift of silt in the rivers. These observations may have practical value for developing engineering measures to control and mitigate the dispersal of snails and their eggs.

Conclusion

Investigations were carried out into specific gravity and dropping speed of snail eggs and an appropriate formula has been devised to link these parameters. Statistical analysis showed no significant difference between measured values and the values predicted from a formula for dropping speed based on Newtonian principles. The result could be used as a basic parameter in the control of *Oncomelania hupensis* when water conservation facilities are designed or rebuilt in areas in which schistosomiasis is endemic.

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